Identifying and Assessing the Patent Landscape for L4/L5 Autonomous Vehicle Technologies

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***Abstract*— Patent landscape information is often used to chart technical developments in important technology domains and to assess relative strengths and weaknesses among competitors developing products using such technologies. Autonomous driving is one such area. This paper describes a methodology for categorizing patents that map to industry-standard definitions of Level 4 and Level 5 autonomous vehicles and provides a "first cut" methodology for assessing relative patent importance using a modified patent citation analysis that eliminates potential self-citation bias and aggregates at the patent family and geographic levels to better map to Intellectual Property ("IP") industry practices and reflect the global market. To test the methodology and simplify the exercise, our search was focused on the 59 manufacturers who had permits to test autonomous vehicles on California, USA streets as of December 4, 2020 [1].**

***Keywords*— Autonomous vehicle, intellectual property, patent landscape, patent analysis, autonomous driving ecosystem**

I. Introduction

A vehicle capable of detecting its environment and operating without a human behind the wheel needed for some aspect of its operation is commonly referred to as a "self-driving vehicle" [2]. Articles about advances in autonomous driving appear in technological and business journals nearly every day, and companies like Tesla have seen the value of their enterprises grow rapidly as developments occur and are reported. The pace of development in this field continues to accelerate on a global scale and has been fueled by literally billions in R&D from a wide variety of companies. And the prize is clear: the worldwide autonomous vehicle ("AV") market is estimated to hit $96 billion by 2025 and grow to nearly $3.5 trillion by 2050. At the same time, analysts estimate that up to 15% of all new vehicles sold in 2030 will be fully self-driving and by 2035 as many as 23 million AVs will be on US roadways [3].

From a technology perspective, self-driving vehicles depend on a wide array of sensors, actuators, cameras, efficient processors, a host of AI and machine learning frameworks, and many other technologies. For example, video cameras distinguish traffic lights, read road signs, track other vehicles, and look for people and objects nearby, and lidar sensors bounce pulses of light off the vehicle's environment to measure separations, distinguish street edges, and distinguish highway markings [2].

As the autonomous vehicle market has matured, efforts have been undertaken to standardize terminology concerning the capabilities that define the levels of autonomous driving functions. A widely adopted lexicon was developed by the Society of Automotive Engineers (SAE) and several other groups, including the US Department of Transportation. Outlined in Fig. 1., the framework is a 1-5 system where Level 1 is a completely manual vehicle and Level 5

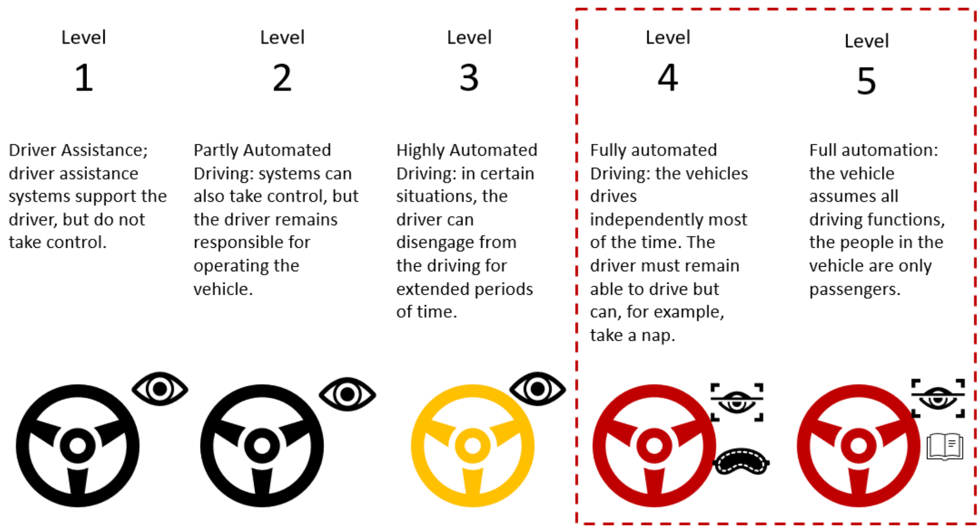


Fig. 1. Five Levels of Autonomous Driving [3]

is a completely independent vehicle with no limitations on where it can drive. In this framework, Level 4 vehicles are recognized to be self-driving, though they incorporate a cockpit such that a driver could still be in control. By contrast, Level 5 connotes “Full Automation,” that is the vehicle can fully operate without human intervention and the vehicle performs all driving duties [4].

An outgrowth of the billions of dollars spent on the R&D, innovations, and technologies that come together to create an autonomous driving experience is a vast amount of intellectual property (IP) that is protectable under the laws of nearly every country. While it is beyond the scope of this paper to explain the types, purposes, and requirements of IP protection, as such information is readily available, for these purposes, we focus on patents: that type of IP where in exchange for disclosing the invention to the public and meeting legal requirements for issuance of a patent, the inventor (or her assignee) is entitled to preclude others from making, using, and selling the patented invention for a period of 20 years. Again, there are a host of details and exceptions in the complex global patent system, but many companies around the world seek and obtain patent protection for their inventions due to the strategic value patents deliver to their owners and other stakeholders.

At the same time, many companies monitor and assess issued and pending patents to gain competitive intelligence and to track and assess strategic opportunities and risks in business functions such as product development, sales, business development, and legal. Google has indexed and made searchable many US and other patents, and the patent offices of many jurisdictions have websites where patents and pending patent applications can be searched [5].

As patents have become very important in many business and technology sectors, companies and others create “landscapes” of patents and patented technologies in a manner that closely mirrors the way venture capitalists and strategic / management consulting / research organizations construct corporate and product landscapes and ecosystems. In the patent world, this kind of landscape often focuses on a particular technology or set of technologies [6], [7].

In our experience, however, what is often missing in published patent reports is a bridge between the market/strategic analyst landscapes and the technology/patent landscapes; in many cases a completely different lexicon is used. Without this bridge, a big portion of data is missing from what should otherwise be a better and more useful analysis.

2020 was not only a transformational year for AV technology but also a major change for the landscape of AV patents. Thus, we decided to look at using the SAE Framework for Transportation as a starting point to categorize patented inventions and the underlying technological innovations that make up the Autonomous Vehicle landscape. We focused on Level 4 and Level 5 because most of the attention, much of the R&D expense, and, quite simply, the future, resides here. To simplify the process and for feasibility reasons, we initially limited our search to the 59 manufacturers who had permits to test autonomous vehicles on California streets as of December 4, 2020 [1].

While this paper provides what we believe to be useful insights into how patents will become increasingly relevant in the autonomous vehicle world, just as they did with 4G and 5G technologies in the communications world, we have made the effort to lay out our search and other patent landscaping methods so others can reproduce them and contribute to their advancement. As further explained below, we have endeavored to normalize the data in the currency of the patent markets – so-called “patent families” -- and to present a distinctly global view because the R&D, productization, use, and patenting efforts are also global.

II. Methods

A. Patent Landscape Methodology

Our landscape was created through a series of iterative searches and analyses using the patent database and tools provided by the Innography software platform owned, and widely licensed to the industry, by CPA Global. As background, patent documents comprise text in which, among other things, inventors are required to fully describe their invention. Using a common approach, patents have sections that include a title, an abstract, a “description of the invention”, and claims (which delimit available legal protection). We used all the above sections in our searches with regards to several factors including a frequency of keyword iteration and keyword weighting.

In addition, we performed searches of technical materials and market literature to identify and extract potentially relevant technological “keywords” and some relevant patents (which we use as “seeds” for searches). Patent classification codes (the schemes used by patent offices to classify patent applications based on the subject matter and route them to patent examiners with experience in those specified fields – think the Dewey Decimal System of patent offices) were also collected, analyzed, and further used to filter candidate keywords to obtain relevant data. In this iterative process, the goal was to search, analyze, and re-search in an attempt to weed out search terms and seeds that yield large numbers of irrelevant patents (“false positives”) while not removing relevant patents (“false negatives”).

Tables I-III. lay out the iterative use of keywords, both sematic and classification, in our study. The asterisk (*) after each word in the keyword query represents an operator that captures different combinations of characters after the actual term, for example, self-driv* includes self-driving, self-drive, etc.

Our search strategy was implemented as follows:

1. Keywords linked to the presence of autonomous Level 4 and 5 technologies were searched in the abstract, title, and claim sections of the patent documents by keyword terms such as: autonomous vehicle, self-driving, driverless, fully automated vehicle, highly automated vehicle, self-parking vehicle, etc. Additionally, keywords from abstract, title, and claim need to be

described further in detail with another set of keywords to collect patents related to the specific subject matter (Level 4 and 5 patents). Some of these keywords are machine learning, deep learning prediction, object detection, trajectory plan, etc.

TABLE I. KEYWORD SEARCH

1. Keyword Search	*@(abstract,claims,title) (("autonomous" OR "self driv*" OR "self-driv*" OR "driverless" OR "automated" OR "fully automat*" OR "fully-automat*" OR "highly automat*" OR "highly-automat*" OR "autopilot" OR "self-park*" OR "self park*" OR "automat* move" OR "automat* moving" OR "automat* guid*" OR "autonomous operation mode") NEAR/10 ("drive" OR "driving" OR =vehicle OR "vehicle" OR "automobil*" OR "bus" OR "van" OR "truck")) AND BODY:("machine learning" OR "artificial intelligence*" OR "neural network*" OR "convolutional neural network*" OR "deep learn*" OR ("predict*" NEAR/5 ("object*" OR "vehicle" OR "pedestrian*" OR "position" OR "behavior")) OR "object detect*" OR "collision avoidance" OR "future behavior" OR "avoid* blind spot*" OR "image recognition" OR "autonomy map*" OR "trajectory plan*" OR "detect* landing strip*" OR ("sensor" NEAR/5 ("read graphic*")) OR ("determin*" NEAR/5 ("position*" OR "speed*" OR "travel*" OR "object" OR "vehicle")) OR "brak* control*" OR "environment* data" OR "plan* navigation route" OR "path plan*" OR "vehicle-to-vehicle communication" OR "vehicle to vehicle communication" OR =V2V OR =DSRC OR "cooperativ* adaptive cruise control*" OR "vehicle to everything communication*" OR "vehicle-to-everything communication*" OR =v2x OR "vehicle-to-infrastructure communication" OR =V2I OR "vehicle to infrastructure communication" OR "Digital Short Range Communication*" OR "Automatic Emergency Brak*") (@* inno_utility_patent)*

2. Development of the patent landscape also involved patent search by the following US Patent Office classes:
   - 701/481: Using Artificial Intelligence (e.g., Neural Network, Etc.);
   - 701/44: Artificial Intelligence (e.g. Fuzzy Logic).

   Patents from the classes were further refined through filtering by an additional set of keywords to exclude false positives.

TABLE II. USP CLASS KEYWORDS

USP Class	*701/481*	*@(abstract,claims,title) ("drive" OR "driving" OR =vehicle OR "vehicle" OR "automobil*")*
	701/44	*(@claims ((“spacecraft” OR “unmanned aerial” OR “stowage” OR “robot*” OR “rail” OR “haulage*” OR “no-automat*” OR “no automat*” OR “non-autonom*” OR “non autonom*” OR “driver assist*” OR “partial automat*”) NEAR/5 ("drive" OR "driving" OR =vehicle OR "vehicle" OR “automobil*” OR “bus” OR “van” OR “truck”))) OR (@title ((“spacecraft” OR “unmanned aerial” OR “stowage” OR “robot*” OR “rail” OR “haulage*” OR “no-automat*” OR “no automat*” OR “non-autonom*” OR “non autonom*” OR “driver assist*” OR “partial automat*”) NEAR/5 ("drive" OR "driving" OR =vehicle OR "vehicle" OR “automobil*” OR “bus” OR “van” OR “truck”))) (@* inno_utility_patent)*

3. Obtained results from the previous phases were assessed and found to have in some instances unacceptable numbers of patents unrelated to the subject matter (Level 4 and 5 technology). Specific terms were excluded, such as technologies that have autonomous driving features but are not the level of interest. Some of the false positive findings / keywords related to: the unmanned aerial vehicle, robot, stowage, spacecraft vehicle, rail vehicle, etc.

TABLE III. REMOVING FALSE POSITIVES KEYWORDS

Removing False Positives	*(@claims ((“spacecraft” OR “unmanned aerial” OR “stowage” OR “robot*” OR “rail” OR “haulage*” OR “no-automat*” OR “no automat*” OR “non-autonom*” OR “non autonom*” OR “driver assist*” OR “partial automat*”) NEAR/5 ("drive" OR "driving" OR =vehicle OR "vehicle" OR “automobil*” OR “bus” OR “van” OR “truck”))) OR (@title ((“spacecraft” OR “unmanned aerial” OR “stowage” OR “robot*” OR “rail” OR “haulage*” OR “no-automat*” OR “no automat*” OR “non-autonom*” OR “non autonom*” OR “driver assist*” OR “partial automat*”) NEAR/5 ("drive" OR "driving" OR =vehicle OR "vehicle" OR “automobil*” OR “bus” OR “van” OR “truck”))) (@* inno_utility_patent)*

As briefly discussed above, before conducting the landscape searches, we investigated numerous publicly available articles on the topic and examined a number of patent documents to help create date boundaries that helped reduce the corpus of information to be searched and reviewed. In this regard, we concluded that 2015 was the appropriate initial time frame to start tracking AV Level 4 and 5 technologies. We may refine this timeline in future analyses, but it is noteworthy that a number of important players in the AV industry (e.g., Zoox, Waymo, Uber, etc.) started filing larger numbers of patent applications relating to Level 4 and 5 patents in that year. This date-based approach also allowed us to remove a large number of false positives (seemingly without affecting relevant patents).

B. Results Classification: Patent Families, Geographic and Citation Analysis

As briefly discussed above, search results were cataloged and classified according to Innography patent family (the patents or applications owned by the same inventive entity and that claim earliest priority from the same patent filing), geographies where patents in the families are being pursued, and a computerized/rough cut “importance” filter based on later filed patents citing to an earlier-filed patent. This simple process, borrowed from the practice of citation analysis of academic papers (and Google’s page rank algorithm), was modified to avoid bias resulting from an organization’s citation of its own earlier work and otherwise serves as a starting spot for “eyes on claims”, which is what most ablebodied patent practitioners will confirm is the only real way to assess "importance".

In filtering results for this paper, we performed this backward citation analysis on all landscape patents of the companies with the license to test AV Levels 4 and 5 in California, USA. And, while later sections of this paper discuss some of those more important patents (and the L4/L5 technologies to which they relate), a much more fulsome analysis is required -- and is beyond the scope of the present work.

III. Results

The Level 4 / Level 5 AV patent landscape produced from the searches described above consists of approximately 16,000 active patents published worldwide, spread among 10,000 active patent families (we excluded from the analysis patents that have been abandoned, for example).

A. Global Patent Activity

The global patent activity in AV technology is shown in Fig. 2., where landscape results are broken down by geographical region [8]. As presented, the major patent activity in Level 4 and 5 technology is in the US with around 5,500 patents, followed by China with approximately 3,700 patents and Europe with around 3,400 patents. The "APAC-xChina" and "Other" geographies were relatively underrepresented. Because our results showed a major increase in relevant patent activity in Q4 of 2020, we looked at the geographical dispersion of such patents, as well. In Q4 2020, the number of patents in the US increased by 11% versus prior activity, while in Europe the increase was 9%. China had the largest increase in Q4 2020, with a 13% increase at the end of the year (2020) versus September 2020.

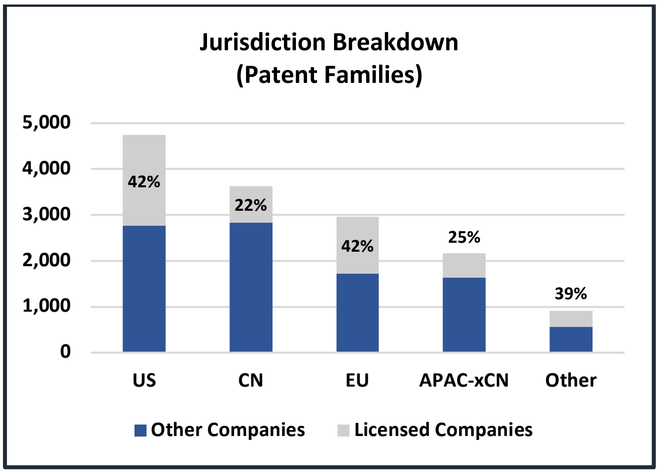


Fig. 2. Jurisdiction Breakdown

B. Priority Date Breakdown

Fig. 3. provides a "priority date" overview of the landscape patents (including the percentage of patent families for those companies which have the license to test AV Level 4 and 5). The priority date of a patent is generally the earliest filing date from within its family of patent applications, and generally speaking, earlier priority dates connote earlier invention and may indicate more important/earlier contributions to the technology field of the innovations described and claimed.

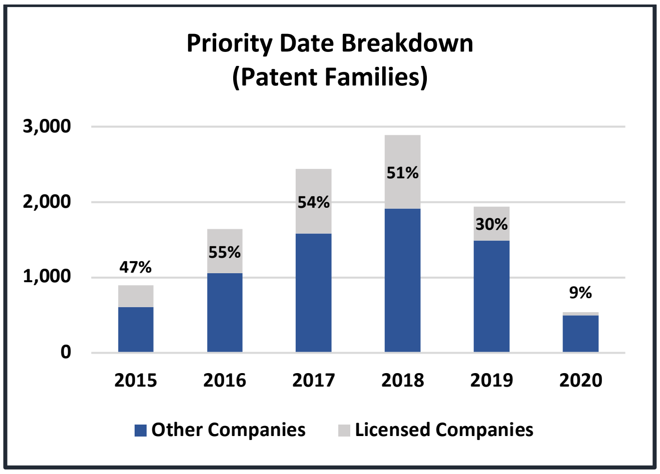


Fig. 3. Priority Date Breakdown

Note: A patent generally is published and viewable to the public only after 18 months have passed from the claimed priority date. As such, in technology areas undergoing recent and rapid development and patent filing, a large number of filed patent applications may be unpublished, meaning: (i) observations and preliminary conclusions may not be indicative of the true body of filings (which will only later become evident); and (ii) results need to be updated frequently – which was one of the reasons for publishing this search analysis as opposed to results analysis. Among other things, it is HIGHLY likely that the 2019 and 2020 numbers will substantially change over time.

Patent activity per priority year significantly varies from 2015 to 2020 as shown in Fig. 3. The patents in the landscape with the earliest priority dates are predominantly assigned to Porsche AG, followed by Ford Motor Company and Shanghai Jiaotong University.

When all relevant patent filings are filtered against priority date based on year (e.g., 2015, 2020, etc.), the data breaks down as follows:

2015: Toyota, Bosch, Ford, and Porsche filings comprise > 26% of all families, while Waymo holds 13th place;

2016: Baidu significantly increases its patent activity (~100%) reaching the 8th position and the first Chinese company is in the top 10. Brand names like BMW and Waymo lose share, but not precipitously;

2017: several companies enter the AV Level 4 and 5 filing space for the first time: e.g., Tusimple, Wipro, Omron; and Uber increases their Level 4 and 5 positions. GM becomes the top filer of L4 and L5 technologies, showing an apparent 67% increase in relevant patent activity compared to 2016;

2018: Baidu posts a 62% increase in patent activity. Toyota, Baidu, GM, and Bosch together comprise ~17% of the total families in the same priority year;

2019 and 2020 are not yet complete due to the 18-month publication rule, but the trend clearly continues in terms of new entrants in L4/L5 filings, as LGE and Stradvision dramatically increased filings.

C. Top Assignees

There are approximately 1,800 companies with at least one patent in the landscape. Fig. 4. aggregates all patents into families as discussed earlier and presents the top 10.

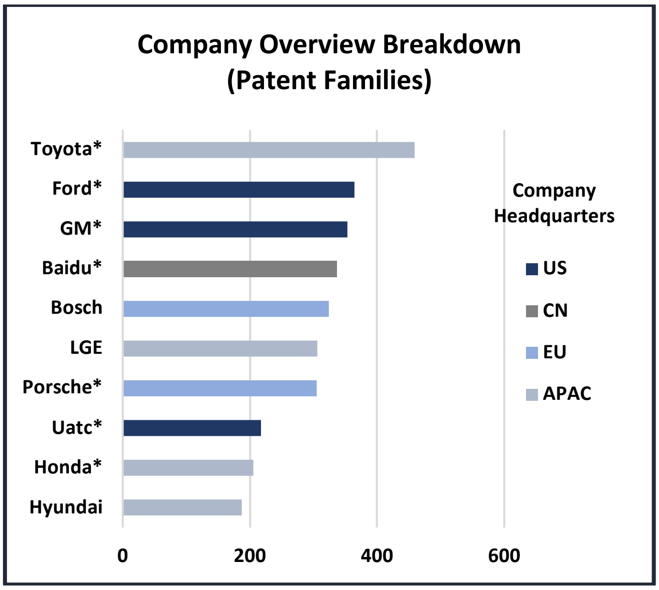


Fig. 4. Company Overview Breakdown

(Note: the asterisk (*) next to the company name in Fig. 4. denotes companies that have received a permit to test AVs in California as of December 4, 2020 [1].)

Almost all companies from the top 10 set of companies in Fig. 4 have the permits to test autonomous vehicles with or without a human in the driver seat. As of this writing, however, 17 of the 59 California AV testing companies have no published patent assets, potentially indicating downstream issues for those companies if patent litigations relating to L4/L5 technologies begin in the next several years, as has been true in other fields. While Tesla was able to maneuver through the field of battery technologies in part by making its patents available to the larger community, even such "open-source" patent strategies are hampered in the absence of a company holding such assets. A variety of strategies to remediate this – such as purchases in the secondary patent markets -- may be available, however.

In addition, 35% of all patent families in the landscape are assigned to companies that have received testing permission in California. These include not only OEMs like Toyota, Ford, and GM, but also newer companies to the market such as Zoox (recently acquired by Amazon), Nio, PlusAI, Pony AI, and DeepMap, with 98, 36, 18, 17, and 16 patent families, respectively. Here, the Q4 2020 analysis is again interesting, as Renault (63% increase on family level), Cruise (50% increase), State Farm (43% increase), Tusimple (38% increase), PlusAI (33% increase) were leaders.

D. Backward Citation Analysis

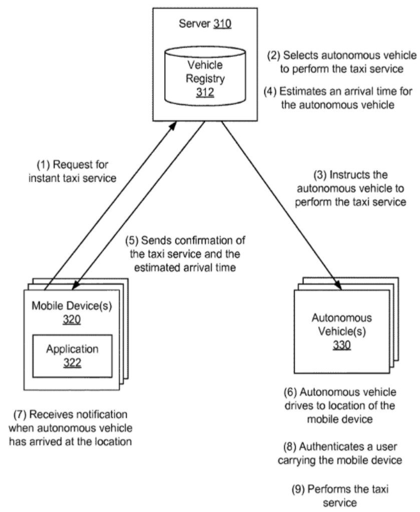
Beyond merely the patent filings and categorizations into L4 and L5 AV, we believe citation analysis of landscape patents by companies with nearer term product readiness (evidenced by licenses to test AV in California) helps one begin to understand what patents might most closely relate to nearer term production. In that regard, we analyzed the references cited in approximately 5,600 patents held by 42 licensed companies (i.e.: their backward citations). Of these citations, 5%, or 997 backward citations, are active patents that relate to AV Level 4 and 5 technologies. Those 997 patents are cited 2,609 times by other patents in the AV Level 4 and 5 space that are assigned to other companies – as stated earlier, the analysis intentionally excludes self-citations.

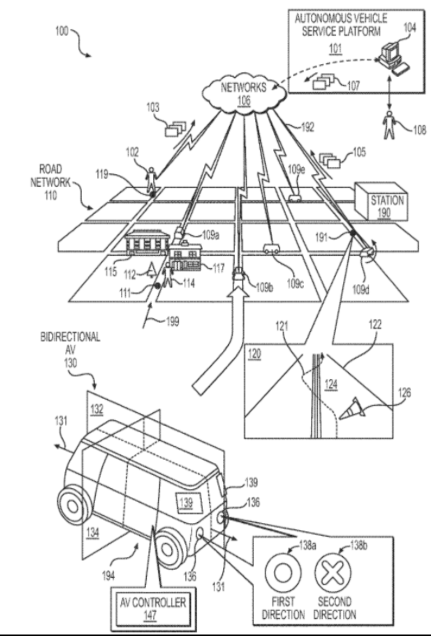
Table IV. below shows the top 20 companies by the number of patents in the AV Level 4 and 5 space that are cited by other companies' patents. 80 of GM's patents in the landscape (including Cruise's) are cited a total of 216 times by AV Level 4 and 5 patents assigned to other companies indicating an industry recognition of these described and claimed inventions. At the same time, Zoox's patents represent ~90% of Amazon's cited patents, and a citation ratio of 6.9 cites per patent potentially indicates a deep pool of patent rights to help protect initiatives on a go forward basis in this emerging market. Lyft, Toyota, and Chinese AV company Nio round out the top 5 with citation ratios of 3.2, 3.0, and 3.7, respectively.

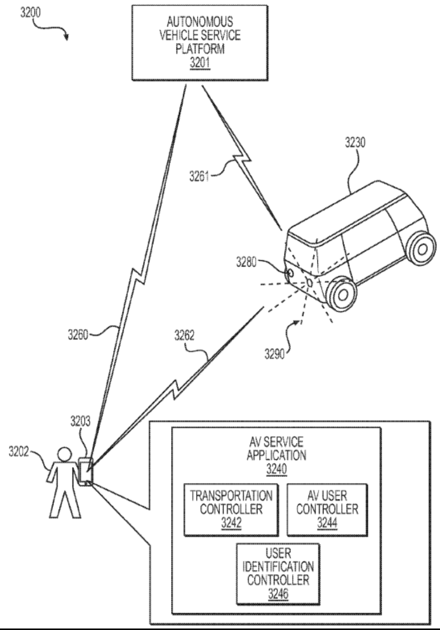
TABLE IV. BACKWARD CITATION ANALYSIS PER COMPANY

Company Name	Number of Companies' Patents Cited by Others	Number of Citations Made by Others
GM (incl. Cruise)	80	216
Uber	75	179
Toyota	74	225
Ford	58	101
Amazon (incl. Zoox)	51	353
Intel	36	76
Alphabet (incl. Waymo)	34	78
Baidu	30	39
Porsche	25	49
IBM	21	47
Geely	18	34
LGE	17	26
Lyft	17	54
Hyundai	16	30
Nio	16	47
DeepMap	15	35
Motional	15	39
Aptiv	15	29
Bosch	15	27
State Farm	15	40

In total, there are 41 patents worldwide that are cited ten or more times by other companies. Twelve patents are assigned to Amazon's subsidiary Zoox, followed by Toyota (five patents), and GM’s subsidiary Cruise (three patents). Citation analysis from Q4 2020 is premature at the moment but will be watched and noted in the next revision of this document. The three most cited patents by other Level 4 and Level 5 patents are summarized below.

Patent Number	US 9,805,605
Title	Using autonomous vehicles in a taxi service
Priority Date	2015-08-12
Publication Date	2017-10-31
Assignee	Madhusoodhan Ramanujam
Inventive Step	Self-driving vehicle performing taxi service autonomously after request and instructions received from a mobile device of the passenger. Autonomous taxi service involves pick up, drop-off location, including other details such as the number of passengers, vehicle type, etc.
Patent Image	

Patent Number	US 9,916,703
Title	Calibration for autonomous vehicle operation
Priority Date	2015-11-04
Publication Date	2018-03-13
Assignee	Zoox, Inc. (Amazon.com, Inc.)
Inventive Step	If an autonomous vehicle controller positioned on a bidirectional autonomous vehicle configured to provide transportation of passengers detects an object on a roadway blocking the trajectory towards a certain position, the autonomous vehicle can transmit a request message to the teleoperator service to help them out with different scenarios. Some of the instructions can be, for example, safely cross a set of double lines to avoid obstacles, etc.
Patent Image	

Patent Number	US 9,958,864
Title	Coordination of dispatching and maintaining fleet of autonomous vehicles
Priority Date	2015-11-04
Publication Date	2018-05-01
Assignee	Zoox, Inc. (Amazon.com, Inc.)
Inventive Step	Self-driving vehicles based on the routing and policy data received from the service platform can navigate the location of origin and autonomously navigate and select routes to a specific location.
Patent Image	

IV. Conclusions and Next Steps

This paper is intended to create a framework for analyzing the patent ecosystem surrounding Level 4 and Level 5 autonomous vehicle technologies that can be updated easily as the landscape evolves and matures. We are proud to have started this process by implementing and refining a method for identifying and aggregating patents that describe and claim the technologies that form the backbone of Level 4 and Level 5 autonomous vehicles. We believe doing so using the lexicon already recognized throughout the industry is an important step in ensuring that the vast landscape of patents that are intended to share and protect the innovations are not simply ignored in a world driven by online search. The iterative, keyword-based method employed here is simply a starting spot. We hope it will be critically reviewed, improved, and refined by the community over time. We welcome that critical review and comment – and we intend to keep improving it as well.

As described earlier, methods we used in conducting the patent landscape included the use of technological keywords and class code searches. The work yielded a full landscape of Level 4 and Level 5 technology patents, which we analyzed and categorized in the common format of the "patent family." We then researched and analyzed data indicative of potential importance and value such as geographic distribution, patent priority date, and backward citation analysis. This included view of companies that have a California permit to test an autonomous vehicle with or without a driver.

With this data cataloged by priority date, ownership, and other parameters, we were able to make a series of observations concerning the fruit of R&D spend on a global level. Early leadership was most evident in US companies, but we expect dramatic increases in filings and issuances from China and other APAC jurisdictions. In 2019, the World Intellectual Property Organization, WIPO, reported that 2020 will likely show rapid development for Japan in the AV industry after an easing of restrictions on self-driving cars [9]. Updates of this landscape should be able to verify and quantify this hypothesis.

As expected, Automotive OEMs such as Toyota, Ford, and GM have the "pole position" in Level 4 / Level 5 patent filings with approximately 400 patent families each. GM's totals were significantly (though not completely) due to acquisitions they made, notably the acquisition of Cruise in 2016. Interestingly, Google subsidiary Waymo, which has at least three years of experience in testing autonomous vehicles in Arizona and California, falls outside of the top 10.

The search method we implemented also allowed us to begin to follow relatively new companies that have entered the market, including US-based companies Zoox (acquired by Amazon) and others, such as PlusAI, Pony AI, Nuro, DeepMap, and Nio. And, as trends are examined – such as the increases found in the 4th quarter of 2020 – it should be noted that Cruise, State Farm, and Renault materially expanded their patent holdings.

Though a somewhat crude indicator of quality, citation analysis helps get a first view of the pioneering aspects of inventions – at least once self-citing is normalized. In this regard, Zoox's patents may deserve extra attention and will be the subject of further review.

Our goal in undertaking this project was to begin to align the world of patents and patent landscapes with the terminology broadly adopted to describe and follow advances made in Level 4 and Level 5 autonomous vehicles. However it is only a start, and we encourage robust comment and refinement.

It will be interesting, for example, to see which technologies and patents (and what taxonomies, if any) are offered by the newly approved University Technology Licensing Program ("UTLP") [10]. This new patent pool identifies "autonomous vehicles" (e.g., millimeter-wave hardware, optical hardware, cybersecurity, sensors) as one of its focus areas. But, to date, UTLP has provided no further details to the public. Because the landscape reported in this paper was limited to selected companies, including university-owned patents could represent a useful improvement to the analysis presented here.

Acknowledgment

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California AV road testing approved companies on December 4, 2020 are: Aimotive, Ambrella, Apex.AI, Apple, Argo, Atlas Robotics, Aurora, Autox, Baidu, BMW, Box Bot, Continental, Cruise, Cyngn, Deeproute, Delphi, DiDi Research, Easymile, Ford, Gatik AI, Helm.AI, Honda, Imagry, Inceptio, Intel, Kaizr, Leonis, Lyft, Mando, Daimler, Navya, Nio, Nissan, Nuro, Nvidia, Phantom, Plusai, Pony, Qcraft, Qualcomm, Renovo Motors, Ridecell, Sf Motors, Subaru, Telenav, Tesla, Thordrive, Toyota, Uber, Uber, Udacity, Udelv, Valeo, Porsche, Voyage, Waymo, WeRide, Xmotors.ai, and Zoox.

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[8] Geographical Regions definitions:
EU (Europe Region): Austria, Belgium, Croatia, Denmark, EPO, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and United Kingdom.
APAC (Asia-Pacific Region x-China): Australia, Hong Kong, India, Japan, New Zealand, Singapore, South Korea, and Taiwan.
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